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Indian Standard

SPECIFICATION FOR
COUPLING DEVICES FOR PLC SYSTEMS

UDC 621.3.052.63 : 621.372.512



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INDIAN STANDARDS INSTITUTION

MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG

NEW DELHI 110002

Price Rs 6-00

Gr 8

March 1979

Indian Standard

SPECIFICATION FOR COUPLING DEVICES FOR PLC SYSTEMS

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Indian Standard

SPECIFICATION FOR COUPLING DEVICES FOR PLC SYSTEMS

0. FOREWORD

0.1 This Indian Standard was adopted by the Indian Standards Institution on 13 November 1978, after the draft finalized by the Power Line Carrier Systems and Associated Telecontrol Equipment Sectional Committee had been approved by the Electronics and Telecommunication Division Council.

0.2 Coupling devices are connected between the coupling capacitor(s) and the carrier-frequency connection to the PLC terminal (or to a similar coupling device, directly or via additional equipment, in the case of retransmission). The coupling device, in conjunction with the coupling capacitor(s) ensures:

- a) the efficient transmission of carrier-frequency signals between the carrier-frequency connection and the power line, and
- b) the safety of personnel and the protection of the low-voltage parts of the installation against the effects of the power frequency voltage and transient overvoltages.

0.3 This standard covers requirements of coupling devices. Methods of tests for coupling devices are covered in IS : 8998-1978*.

0.4 While preparing this standard, assistance has been derived from IEC Pub 481 (1974) 'Coupling devices for power line carrier systems', issued by the International Electrotechnical Commission.

0.5 For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960†. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

1. SCOPE

1.1 This standard covers performance requirements of coupling devices for power line carrier (PLC) systems.

*Methods of tests for coupling devices for PLC systems.

†Rules for rounding off numerical values (*revised*).

2. TERMINOLOGY

2.0 For the purpose of this standard, the following definitions shall apply.

2.1 Methods of Coupling

2.1.1 Phase-to-Earth Coupling — Coupling to the power line effected between the conductor(s) of one phase of the line and earth (*see* Fig. 1A and 2).

2.1.2 Phase-to-Phase Coupling — Coupling to the power line effected between the conductor(s) of one phase and the conductor(s) of another phase of the same line (*see* Fig. 1B and 1C). The two phases may belong to the same circuit or to different circuits of the power line (intercircuit coupling).

NOTE 1 — Coupling is usually effected to one or more phase conductors of the power line (poles in the case of dc power line), phase-to-earth and phase-to-phase being the most common forms of coupling. Coupling to all three phases of a circuit may be required in certain cases. Coupling to one or more associated insulated earth-wire conductors is also employed.

NOTE 2 — Coupling between individual conductors of a phase bundle is a special application.

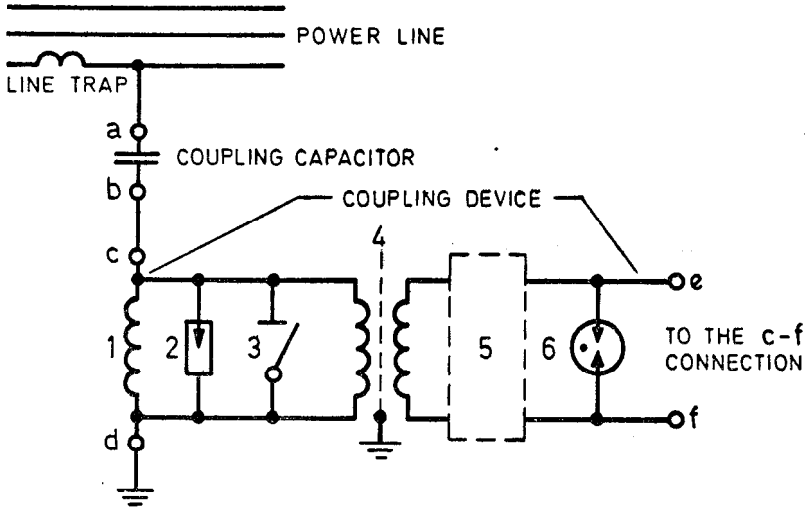
2.2 Coupling Devices and Terminals

2.2.1 Coupling Device — An arrangement of elements which contribute to ensure, together with one or more associated coupling capacitors, the transmission, under prescribed conditions, of carrier-frequency signals between one or more conductors of the power line and the carrier-frequency connection (*see* Fig. 1 and 2).

2.2.1.1 These elements, alone or together, contribute to all, or part of, the following functions :

- a) Tuning, designed to compensate for the reactive component of the coupling capacitor(s) impedance, in order to promote the efficient transmission of carrier-frequency signals. This function may be performed by a tuning device;
- b) Impedance matching between the power line and the carrier-frequency connection. This function may be performed by a transformer;
- c) Galvanic isolation between primary and secondary terminals of the coupling device. This function may be performed by the abovementioned transformer;
- d) Draining to earth of the power-frequency current derived by the coupling capacitor(s). This function may be performed by an inductance, termed drain coil;

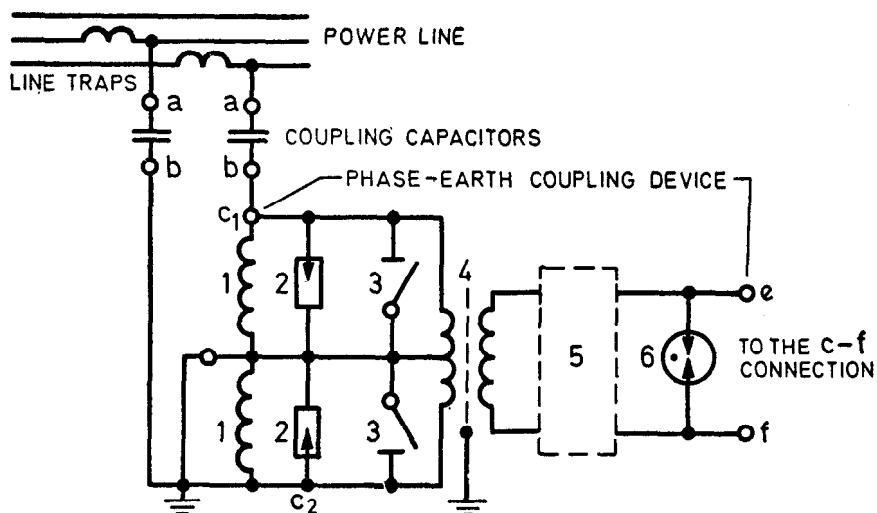
- e) Limitation of voltage surges coming from the power line, at the terminals of the coupling device. This function may be performed by lightning arresters suitably arranged in the coupling device; and
- f) Direct and efficient earthing, when necessary, of the primary terminal(s) of the coupling device. This function may be performed by an earthing switch.



1. Drain Coil
2. Main Arrester
3. Earthing Switch
4. Matching and Isolation Transformer
5. Tuning Device
6. Secondary Arrester

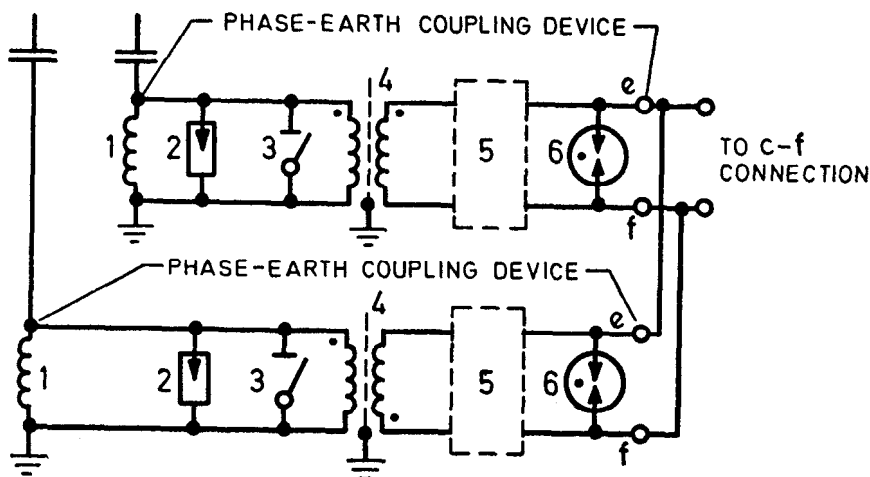
- a = High-voltage terminal of coupling capacitor
 b = Low-voltage terminal of coupling capacitor
 c, c₁, c₂ = Primary terminals of coupling device
 d = Earth terminal of coupling device
 e, f = Secondary terminals of coupling device

1A Phase-Earth Coupling



NOTE — See Fig. 1A for explanations.

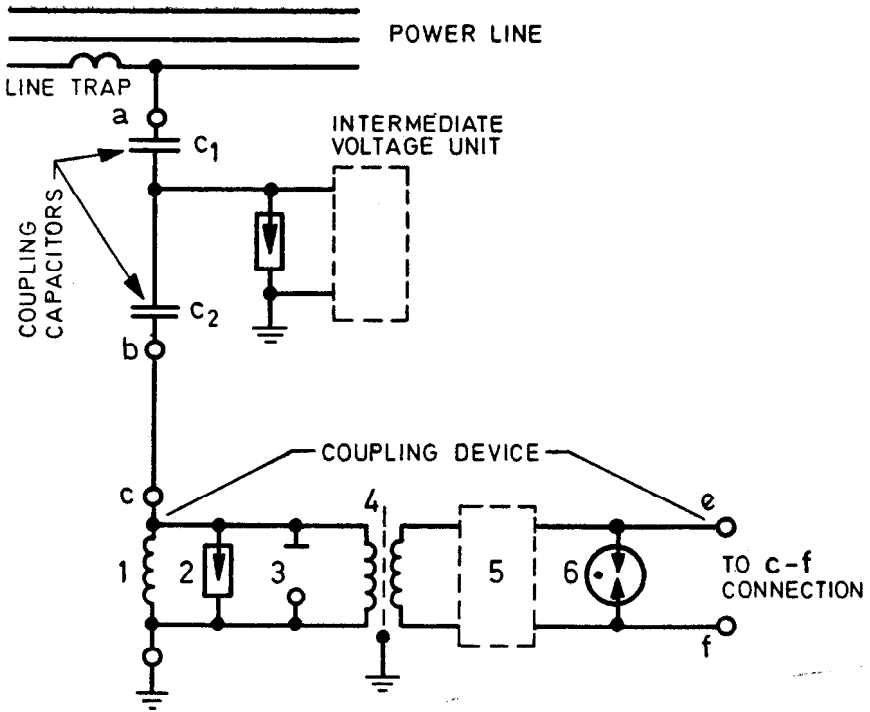
1B Coupling Between Two Phases Using A Phase-to-Phase Coupling Device



NOTE — See Fig. 1A for explanations.

1C Coupling Between Two Phases with Two Phase-Earth Coupling Devices

FIG. 1 EXAMPLES OF COUPLING



C_1 = High voltage capacitor

C_2 = Intermediate voltage capacitor

NOTE — See Fig. 1A for explanations.

FIG. 2 EXAMPLES OF COUPLING THROUGH A CAPACITOR
VOLTAGE TRANSFORMER

2.2.2 Earth Terminal — A terminal of the coupling device which is intended to be connected directly to the local station earth.

2.2.3 Primary Terminal — A terminal of the coupling device which is intended to be connected to the low-voltage terminal of the coupling capacitor.

2.2.4 Secondary Terminal — A terminal of the coupling device which is intended to be connected to the carrier-frequency connection.

2.3 Communication Terms for Coupling Devices

2.3.1 Nominal Line-Side Impedance (Z_1) — The impedance which the coupling device, together with the associated coupling capacitor(s), is designed to match on the line side, and to which the requirements refer (see Fig. 3).

2.3.2 Nominal Equipment-Side Impedance (Z_2) — The impedance which the coupling device is designed to match, on the equipment side, and to which the requirements refer (see Fig. 3).

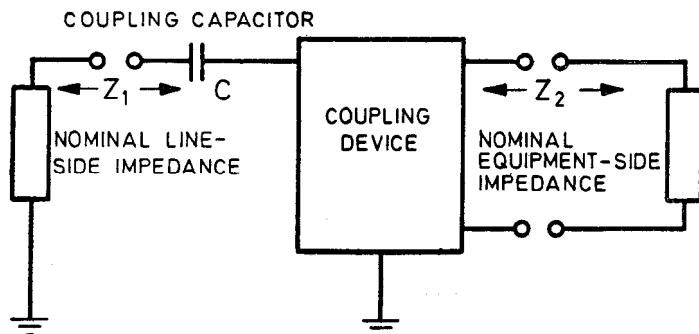


FIG. 3 NOMINAL IMPEDANCES FOR A PHASE-EARTH COUPLING DEVICE

2.3.3 Composite Loss — The composite loss brought about by the quadripole made up of the coupling device and associated coupling capacitor(s) having the specified capacitance and assumed to have no losses, terminated by the nominal line-side and equipment-side impedance.

2.3.4 Return Loss — The return loss of the quadripole made up of the coupling device and associated coupling capacitor(s) having the specified capacitance and assumed to have no loss, respectively terminated by the nominal line-side and equipment-side impedance.

2.3.5 Available Bandwidth — The frequency band within which the composite loss does not exceed, and the return losses do not fall short of the specified values.

2.3.6 Carrier-Frequency Working Range — The range of carrier frequencies within which the available bandwidth of a coupling device can be set.

2.3.7 Nominal Peak-Envelope Power — The peak-envelope power for which the coupling device has been designed compatible with the requirements for intermodulation.

NOTE — In case of double side band, nominal power shall be the carrier power plus the side band power with 100 percent modulation at a frequency of 800 Hz.

3. SERVICE CONDITIONS

3.0 Unless otherwise specified, coupling devices shall be suitable for operation in the service conditions given below.

3.1 Exposure — Outdoor service, exposed to sunshine, rain, fog, hail, frost, snow, ice, etc.

3.2 Altitude — The height above sea level shall be up to and including 1 000 m.

3.3 Ambient Temperature — Unless otherwise agreed between manufacturer and purchaser, the ambient temperature shall be between -5°C and $+50^{\circ}\text{C}$ and shall not exceed the following limits:

- a) $+40^{\circ}\text{C}$ for the daily average, and
- b) $+32^{\circ}\text{C}$ for the annual average.

3.4 Power Frequency — Power systems shall have a rated frequency between zero (dc) and 60 Hz inclusive.

3.5 Operating Voltage — The rated operating voltage of the power line shall be not less than 1 000 V.

3.6 Provision for Unusual Service Conditions — In all cases where the above conditions are not met and severe atmospheric conditions such as salt spray and industrial pollution are to be expected, special arrangements should be made between manufacturer and purchaser.

4. REQUIREMENTS

4.1 Safety and Protection Requirements of the Coupling Device

4.1.1 General — The coupling device shall meet the following requirements irrespective of whether or not the protective devices of an associated coupling capacitor or capacitor voltage transformer contribute to the safety and protection of the coupling device. The design of the coupling device shall be such as to prevent the occurrence of dangerous potentials on the carrier-frequency connection due to the service voltage or transient overvoltages which may occur on the power line.

NOTE — There are two types of transient overvoltages to be taken into account:

- a) Overvoltages due chiefly to the operation of switchgear. Such overvoltages may have amplitudes of the same order of magnitude as the service voltage and be transferred to the low-voltage side of the coupling capacitor because of the steep-fronted or high-frequency nature of the transients; and
- b) Atmospheric overvoltages which are also transferred to the low-voltage side of the coupling capacitor for the same reason.

The coupling device shall be designed and built to ensure that a fault on the power line shall not in general cause a permanent interruption in the functioning of the coupling device. If, under abnormal power-system conditions, the values specified in 4.1.5, 4.2.1 and 4.2.2 are exceeded, this shall be a matter for special agreement between manufacturer and purchaser.

4.1.2 Earthing of the Primary Terminal — The coupling device shall be so designed that the impedance at power frequency between the primary terminal and the earth terminal is as low as possible and in no case in excess of 20Ω . This low impedance shall be ensured by a device such as a drain coil or matching transformer winding as specified in 4.1.3.

4.1.3 Drain Coil Winding — The drain coil winding shall:

- a) offer a maximum guarantee of continuity of connection to the earth terminal; and
- b) withstand any of the above mentioned overvoltages which may occur on the power line, taking into account the effect of the main arrester (see 4.1.5).

4.1.4 Earthing Switch — An earthing switch shall be provided for making a temporary direct connection between the primary and earth terminals. The rated current of the earthing switch shall be not less than 200 A.

The method of operating the earthing switch shall take due regard of requirements for safety in accordance with the IE Rules.

In case earthing switch is enclosed, an indication of 'on' and 'off' positions of the earthing switch shall be clearly visible.

4.1.5 Main Arrester — A lightning arrester shall be connected as directly as possible between the primary and earth terminals and shall be capable of protecting the coupling device and the carrier-frequency connection. The lightning arrester shall be of non-linear resistor type [see IS : 3070 (Part I)-1974*].

NOTE 1 — It is recommended that rated voltage of the lightning arrester be of the order of 1 kV (corresponding to an impulse sparkover voltage of about 4 kV) and that it be able to sustain an impulse discharge current of wave shape 8/20 μ s of at least 5 kA [see IS : 2071† and IS : 3070 (Part I)-1974*].

NOTE 2 — Where the coupling capacitor is remote from the coupling device, it may be necessary to provide, at the coupling capacitor, an additional arrester, similar to the main arrester.

*Specification for lightning arresters for alternating current systems : Part I Non-linear resistor type lightning arresters.

†Methods of high voltage testing (first revision).

NOTE 3 — It may be advisable, both for the protection of the carrier-frequency connection and the PLC terminal, to provide an arrester which will limit the voltage across the secondary terminals of the coupling device to a value compatible with the withstand voltage of the carrier-frequency connection and that of the protection device, if any, at the other end of the carrier-frequency connection. Gas-type arresters, having a power-frequency sparkover voltage of the order of a few hundred volts are generally suitable.

4.2 Insulation Requirements

4.2.1 Power Frequency Level — For the isolation between primary and secondary terminals of the coupling device, the power frequency voltage tests shall be applied using a voltage of 5 kV rms for one minute.

4.2.2 Impulse Level — The coupling device shall be so designed as to be able to withstand a $1.2/50 \mu\text{s}$ impulse voltage of 10 kV (peak).

4.3 Carrier-Frequency Requirements

4.3.1 Composite Loss — The composite loss shall be the least possible compatible with the bandwidth and design requirements called for by safety considerations and shall be not greater than 2 dB over the whole of the available bandwidth of the coupling device.

4.3.2 Return Loss — The line-side and equipment-side return losses shall preferably be not less than 12 dB over the whole of the available bandwidth of the coupling device. In certain cases, values less than 12 dB may require to be accepted, subject to agreement between manufacturer and purchaser.

4.3.3 Nominal Line-Side Impedance — The nominal line-side impedance shall line in the range 200 to 400 Ω for phase-to-earth coupling and in the range 400 to 700 Ω for phase-to-phase coupling.

NOTE — These ranges of impedance are derived from the parallel combination of the most common line-trap and line impedances in the case of overhead power lines. Special applications such as underground power cables or insulated earth wires would be subject to agreement between manufacturer and purchaser.

In certain cases, the coupling device may offer the facility of being set to several different nominal line-side impedance values, if called for by the purchaser.

4.3.4 Nominal Equipment-Side Impedance — The nominal equipment-side impedance of the coupling device shall be 75 Ω (unbalanced) or 150 Ω (balanced). Other values would be subject to agreement between manufacturer and purchaser.

4.3.5 Carrier-Frequency Working Range — The carrier-frequency working range of the coupling device shall be subject to agreement between manufacturer and purchaser.

4.3.6 Distortion and Intermodulation — The level of individual distortion and intermodulation products arising within the coupling device shall be atleast 80 dB below the level corresponding to the peak-envelope power.

5. MARKING

5.1 The coupling device shall be provided with a rating plate of weather-proof material, fitted so that it is readily visible. The inscriptions shall be indelibly marked. The rating plate shall give the following data:

- a) Manufacturer's name;
- b) Type;
- c) Manufacturer's serial number;
- d) Nominal peak-envelope power;
- e) Capacitance of coupling capacitor to which the carrier-frequency requirements of the coupling device are referred;
- f) Nominal line-side and equipment-side impedances; and
- g) Available bandwidth or carrier-frequency working range.

NOTE — Where it is not possible to include all the above data on the rating plate, or additional data are required such as, for example, information on the relative polarities of the transformer windings, other means of informing the user shall be provided.

5.1.1 The coupling device may also be marked with the ISI Certification Mark.

NOTE — The use of the ISI Certification Mark is governed by the provisions of the Indian Standards Institution (Certification Marks) Act and the Rules and Regulations made thereunder. The ISI Mark on products covered by an Indian Standard conveys the assurance that they have been produced to comply with the requirements of that standard under a well-defined system of inspection, testing and quality control which is devised and supervised by ISI and operated by the producer. ISI marked products are also continuously checked by ISI for conformity to that standard as a further safeguard. Details of conditions, under which a licence for the use of the ISI Certification Mark may be granted to manufacturers or processors, may be obtained from the Indian Standards Institution.